(54)   Oscillation circuit and oscillation method

(57)   NPN transistors are differentially connected to each other. The signal output from the collector of a first NPN transistor is positively fed back to the base of a second NPN transistor via a first capacitor, and the signal output from the collector of the second NPN transistor is positively fed back to the base of the first NPN transistor via a second capacitor. A one-port-type SAW resonator is connected to the collectors of the NPN transistors via the capacitors for blocking the flow of direct current. Thus, it becomes possible to generate a high-frequency signal with a high degree of accuracy.

FIG. 1

Description

The present invention relates to an oscillation circuit and an oscillation method and, more particularly, to an oscillation circuit and an oscillation method in which signals having a high frequency can be generated without adjustments.

Fig. 3 shows an example of the construction of an oscillation circuit. In this example, the emitter of an NPN transistor 3 is grounded via a resistor 4, and a capacitor 6 is connected in parallel to the resistor 4. Further, a capacitor 5 is connected between the base and the emitter of the NPN transistor 3. A resistor 1 and a resistor 2 are connected between a terminal T_3 which is connected to a predetermined voltage source and the ground, with the connection point of the resistor 1 and the resistor 2 being connected to the base of the NPN transistor 3. Each of these resistors 1, 2 and 4 supplies a predetermined bias voltage to the NPN transistor 3.

Further, connected to the base of the NPN transistor 3 is a one-port-type SAW (Surface Acoustic Wave) resonator 9 via a capacitor 7 for blocking the flow of direct current. In addition, a terminal T_3 is grounded via a capacitor 8.

The one-port-type SAW resonator 9 is formed as shown in, for example, Fig. 4, and the equivalent circuit thereof is formed as shown in Fig. 5.

More specifically, a parallel circuit of (i) a series circuit formed of a resistor 21, a coil 22 and a capacitor 23 and (ii) a capacitor 24 is connected between terminals T_1 and T_2. This capacitor 24 is a terminal-to-terminal capacitance of the one-port-type SAW resonator 9.

This one-port-type SAW resonator 9 substantially functions as an inductance when the conditions described below are satisfied, where L_{22}, C_{23}, C_{24} and R_{21} are the inductance of the coil 22, the capacitance of the capacitor 23, the capacitance of the capacitor 24 and the resistance value of the resistor 21, respectively:

$$\omega L_{22} > 1/(\omega C_{23}) = 1/(\omega C_{24}) = R_{21}$$

That is, when the one-port-type SAW resonator 9 satisfies the above-described conditions and substantially functions as an inductance (coil), the circuit of Fig. 3 forms a what is commonly called Colpitts oscillation circuit and performs an oscillation operation.

In the oscillation circuit shown in Fig. 3, a two-port-type SAW resonator 43 shown in Figs. 7 and 8 to be described later may be used instead of the one-port-type SAW resonator 9 shown in Figs. 4 and 5.

Fig. 6 shows an example of the construction of another oscillation circuit. In this example, the output of an amplifier 41 is fed to the two-port-type SAW resonator 43 via a capacitor 42. Further, the output of the two-port-type SAW resonator 43 is input to the amplifier 41 via a capacitor 44.

The amplifier 41 is contained in an IC, and the in-ductance components, such as a bonding wire present between each terminal of the IC and the built-in chip, form a coil 45.

The two-port-type SAW resonator 43 has terminals T_{11} and T_{12} for input/output purposes and terminal T_{13} for grounding purposes, as shown in, for example, Fig. 7. Fig. 8 shows an equivalent circuit of such two-port-type SAW resonator 43.

That is, the terminal T_{11} is connected to one of the terminals of one of the windings of an equivalent transformer 55 via a resistor 52, a coil 53 and a capacitor 54. The other terminal of this winding of the equivalent transformer 55 is connected to the terminal T_{13}. The terminal T_{11} is connected to the terminal T_{13} via a capacitor 51.

The terminal T_{12} is connected to the terminal T_{13} via a parallel circuit of the other winding of the equivalent transformer 55 and a capacitor 56.

The two-port-type SAW resonator 43 substantially functions as a delay phase circuit and is formed to be able to select delay phase signals of 0 and 180 degrees mainly by the coil 53 and the equivalent transformer 55.

Therefore, the output of the amplifier 41 is input to the two-port-type SAW resonator 43 via the capacitor 42, and a signal whose phase is delayed 0 or 180 degrees is input from the two-port-type SAW resonator 43 via the capacitor 44 to the amplifier 41, causing this circuit to oscillate.

However, the above-described oscillation circuit shown in Fig. 3 performs an unbalanced operation. As a result, in order to suppress leakage of the oscillation signal (spurious signal), a power terminal T_3 must be grounded in a high-frequency manner by the capacitor 8 so as to decrease the impedance thereof and stabilize the circuit. Also, it is necessary to strictly shield the entire oscillation circuit. Furthermore, there are problems, for example, since the degree of balance is poor, loopback of signals occurs, and therefore in order to stably generate a signal of a predetermined frequency without being affected by temperature change or aging, an adjustment operation is indispensable.

Meanwhile, since the oscillation circuit shown in Fig. 6 also performs an unbalanced operation, countermeasures for factors which obstruct the formation of ICs of a small size and integration of ICs must be performed, for example, independent power terminals are provided to make high-frequency grounding easy, or the number of parallel grounding terminals is increased. As a result, only signals of a frequency of, for example, 100 MHz, can be generated, and there is a problem in that it is difficult to stably generate a signal of a frequency higher than that frequency without being affected by temperature change or aging.

The present invention has been achieved in view of such circumstances and aims to stably generate a signal of a higher frequency.

The oscillation circuit described in claim 1 comprises: a differential amplifier having at least a pair of active

elements which are differentially connected; a positive feedback circuit for positively feeding back the output of the differential amplifier to the input thereof; and a one-port-type SAW resonator connected between the pair of active elements.

The oscillation method described in claim 13 comprises the steps of: positively feeding back the output of a differential amplifier having at least a pair of active elements which are differentially connected to the input thereof; and causing a one-port-type SAW resonator connected between the pair of active elements to perform an oscillation operation.

In the oscillation circuit described in claim 1, the differential amplifier includes at least a pair of active elements which are differentially connected, a positive feedback circuit for positively feeding back the output of the differential amplifier to its input, and a one-port-type SAW resonator is connected between a pair of active elements.

In the oscillation method described in claim 13, the output of a differential amplifier having at least a pair of active elements which are differentially connected is positively fed back to the input thereof, and a one-port-type SAW resonator connected between the pair of active elements is caused to perform an oscillation operation.

The above and further objects, aspects and novel features of the invention will become more apparent from the following detailed description when read in connection with the accompanying drawings, in which:

Fig. 1 is a circuit diagram illustrating the construction of an embodiment of an oscillation circuit of the present invention;
Fig. 2 is a circuit diagram illustrating the construction of another embodiment of the oscillation circuit of the present invention;
Fig. 3 is a circuit diagram illustrating the construction of the oscillation circuit;
Fig. 4 shows the construction of a one-port-type SAW resonator;
Fig. 5 is a circuit diagram illustrating an equivalent circuit of the example of Fig. 4;
Fig. 6 is a circuit diagram illustrating an example of the construction of another oscillation circuit;
Fig. 7 shows the construction of a two-port-type SAW resonator; and
Fig. 8 is a circuit diagram illustrating an equivalent circuit of the example of Fig. 7.

Fig. 1 is a circuit diagram illustrating the construction of an embodiment of an oscillation circuit of the present invention (however, the illustration of the biases of the transistors 61 and 62 are omitted). In this embodiment, the emitters of NPN transistors 61 and 62 serving as bipolar transistors are connected in common, with the common connection point being grounded via a constant-current circuit 63. The collector of the NPN tran-

sistor 61 is connected to a power terminal 70 via a load impedance 64, and the collector of the NPN transistor 62 is connected to the power terminal 70 via a load impedance 65. That is, the NPN transistor 61 and the NPN transistor are differentially connected to form a differential amplifier.

Also, the collector of the NPN transistor 61 is connected to the base of the NPN transistor 62 via a capacitor 67, and the collector of the NPN transistor 62 is connected to the base of the NPN transistor 61 via a capacitor 66. That is, one of the outputs of the differentially connected NPN transistors 61 and 62 is positively fed back to the input of the other transistor. The capacitors 66 and 67 form a positive feedback circuit for this purpose.

Further, the collectors of the NPN transistors 61 and 62 are connected to the terminals T_1 and T_2 of the one-port-type SAW resonator 9 via capacitors 68 and 69 for blocking the flow of direct current, respectively. The one-port-type SAW resonator 9, as described above, is formed in such a shape as that shown in Fig. 4, and the equivalent circuit thereof is formed as shown in Fig. 5.

The output of the collector of the NPN transistor 61 is positively fed back to the base of the NPN transistor 62 via the capacitor 67. Also, the output of the collector of the NPN transistor 62 is positively fed back to the base of the NPN transistor 61 via a capacitor 66. As a result, this oscillation circuit substantially oscillates in a parallel resonance mode defined substantially by the values (C_{24} and L_{22}) of the capacitor 24 and the coil 22 of the one-port-type SAW resonator 9.

When it is assumed that the parameters of the NPN transistors 61 and 62 are the same, the values of the load impedances 64 and 65 are equal to each other, the values of the capacitors 68 and 69 are equal to each other, and the values of the capacitors 66 and 67 are equal to each other ($Z_{64} = Z_{65}$, $C_{68} = C_{69}$, and $C_{66} = C_{67}$), and this oscillation circuit reaches a completely balanced state. Since a completely balanced state is reached, in the power terminal 70 and the emitters of the NPN transistors 61 and 62, the opposite-phase amplitude components are canceled with each other, and they reach a virtually grounded state. Therefore, an oscillation circuit which does not require a high-frequency grounding terminal for suppressing a spurious signal and having a small amount of leakage can be realized.

Also, since a completely balanced circuit is formed, adjustments are not required, and an oscillation operation can be performed stably and with a high degree of accuracy regardless of temperature change or aging.

For example, it is required that the second intermediate frequency signal in a digital television broadcast have a high frequency of 480 MHz, and its accuracy be in the range of ±100 kHz. According to the embodiment of Fig. 1, it is possible to generate such high-frequency signal with the required accuracy and without adjustments.

When the circuit shown in Fig. 5 is formed from parts

Description

The present invention relates to an oscillation circuit and an oscillation method and, more particularly. to an oscillation circuit and an oscillation method in which signals having a high frequency can be generated without adjustments.

Fig. 3 shows an example of the construction of an oscillation circuit. In this example, the emitter of an NPN transistor 3 is grounded via a resistor 4, and a capacitor 6 is connected in parallel to the resistor 4. Further, a capacitor 5 is connected between the base and the emitter of the NPN transistor 3. A resistor 1 and a resistor 2 are connected between a terminal T_3 which is connected to a predetermined voltage source and the ground, with the connection point of the resistor 1 and the resistor 2 being connected to the base of the NPN transistor 3. Each of these resistors 1, 2 and 4 supplies a predetermined bias voltage to the NPN transistor 3.

Further, connected to the base of the NPN transistor 3 is a one-port-type SAW (Surface Acoustic Wave) resonator 9 via a capacitor 7 for blocking the flow of direct current. In addition, a terminal T_3 is grounded via a capacitor 8.

The one-port-type SAW resonator 9 is formed as shown in, for example, Fig. 4, and the equivalent circuit thereof is formed as shown in Fig. 5.

More specifically, a parallel circuit of (i) a series circuit formed of a resistor 21, a coil 22 and a capacitor 23 and (ii) a capacitor 24 is connected between terminals T_1 and T_2. This capacitor 24 is a terminal-to-terminal capacitance of the one-port-type SAW resonator 9.

This one-port-type SAW resonator 9 substantially functions as an inductance when the conditions described below are satisfied, where L_{22}, C_{23}, C_{24} and R_{21} are the inductance of the coil 22, the capacitance of the capacitor 23, the capacitance of the capacitor 24 and the resistance value of the resistor 21, respectively:

$$\omega L_{22} > 1/(\omega C_{23}) = 1/(\omega C_{24}) = R_{21}$$

That is, when the one-port-type SAW resonator 9 satisfies the above-described conditions and substantially functions as an inductance (coil), the circuit of Fig. 3 forms a what is commonly called Colpitts oscillation circuit and performs an oscillation operation.

In the oscillation circuit shown in Fig. 3, a two-port-type SAW resonator 43 shown in Figs. 7 and 8 to be described later may be used instead of the one-port-type SAW resonator 9 shown in Figs. 4 and 5.

Fig. 6 shows an example of the construction of another oscillation circuit. In this example, the output of an amplifier 41 is fed to the two-port-type SAW resonator 43 via a capacitor 42. Further, the output of the two-port-type SAW resonator 43 is input to the amplifier 41 via a capacitor 44

The amplifier 41 is contained in an IC, and the in-

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form a coil 45.

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7. Fig 8 shows an equiv
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The present invention
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The oscillation circuit
es a differential amplifier

the base of a second bipolar transistor which forms said differential amplifier; and

a second capacitor which connects the collector of said second bipolar transistor to the base of said first bipolar transistor.

6. An oscillation circuit according to claim 3, wherein the collectors of said pair of bipolar transistors are each connected to the power source via a pair of load impedances, and the emitters of said pair of bipolar transistors are connected in common, with the common connection point being grounded via a constant-current circuit.

7. An oscillation circuit according to claim 3, wherein said one-port-type SAW resonator is connected between the collectors of a pair of said bipolar transistors each via a pair of capacitors for blocking the flow of direct current,

said positive feedback circuit comprises a pair of capacitors for positive feedback which connect one of the collectors of said pair of bipolar transistors is connected to the base of the other transistor, the collectors of said pair of bipolar transistors are each connected to a power source via a pair of load impedances, and the capacitances of said pair of capacitors for blocking the flow of direct current are made to be equal to each other, the capacitances of said pair of capacitors for positive feedback are made to be equal to each other, and the impedances of said pair of load impedances are made to be equal to each other.

8. An oscillation circuit according to claim 2, wherein said one-port-type SAW resonator is connected between the bases of said bipolar transistors.

9. An oscillation circuit according to claim 8, wherein said one-port-type SAW resonator is connected between the bases of said pair of said bipolar transistors each via a pair of capacitors for blocking the flow of direct current.

10. An oscillation circuit according to claim 8, wherein said positive feedback circuit comprises a first capacitor which connects the emitter of a first bipolar transistor which forms said differential amplifier to the base of said bipolar transistor; and

a second capacitor which connects the emitter of said second bipolar transistor which forms said differential amplifier to the base of said bipolar transistor.

11. An oscillation circuit according to claim 8, wherein the collectors of said pair of bipolar transistors are

connected in common, with the common connection point being connected to the power source, and the emitters of said pair of bipolar transistors are grounded each via a constant-current circuit.

12. An oscillation circuit according to claim 8, wherein said one-port-type SAW resonator is connected between the bases of said pair of bipolar transistors each via a pair of capacitors for blocking the flow of direct current,

said positive feedback circuit comprises a pair of capacitors for positive feedback, each of which capacitors connects the emitter of one of said pair of bipolar transistors to the base of the other transistor, and the capacitances of said capacitors for blocking the flow of direct current are made to be equal to each other, and the capacitances of said capacitors for positive feedback are made to be equal to each other.

13. An oscillation method for generating a high-frequency signal, said method comprising the steps of:

positively feeding back the output of a differential amplifier having at least a pair of active elements which are differentially connected to the input thereof; and causing a one-port-type SAW resonator connected between said pair of active elements to perform an oscillation operation.

14. An oscillation method according to claim 13, wherein the output from said pair of active elements is input to said one-port-type SAW resonator after the direct current components are removed.

15. An oscillation method according to claim 14, wherein said positive feedback is performed in such a way that the output from the collector of a first bipolar transistor which forms said differential amplifier is fed back to the base of a second bipolar transistor which forms said differential amplifier via a first capacitor, and that the output from the collector of said second bipolar transistor is fed back to the base of a first bipolar transistor via a second capacitor.

16. An oscillation method according to claim 14, wherein said positive feedback is performed in such a way that the output from the emitter of a first bipolar transistor which forms said differential amplifier is fed back to the base of the bipolar transistor via a first capacitor, and that the output from the emitter of a second bipolar transistor which forms said differential amplifier is fed back to the base of the bipolar transistor via a second capacitor.

of discrete resistors, coils and capacitors in place of the one-port-type SAW resonator 9, the circuit is affected by temperature change, ageing or the like, and it becomes difficult to generate a high-frequency signal with a high degree of accuracy. Therefore, it becomes necessary to use a one-port-type SAW resonator.

Fig. 2 shows the construction of a second embodiment of an oscillation circuit of the present invention. In this embodiment, the collector of an NPN transistor 81 is connected to a power terminal 91, and the emitter thereof is connected to a constant-power source 85. Further, the collector of an NPN transistor 82 is also connected to the power terminal 91, and the emitter thereof is connected to a constant-power source 86. Furthermore, the emitters of the NPN transistors 81 and 82 are connected to each other via a capacitor 87, and thus these transistors form a differential amplifier.

Further, in this embodiment, the signal output from the emitter of the NPN transistor 81 is positively fed back to the base of the NPN transistor 81 via a capacitor 83, and the signal output from the emitter of the NPN transistor 82 is positively fed back to the base of the NPN transistor 82 via a capacitor 84. Furthermore, terminals T_1 and T_2 of the one-port-type SAW resonator 9 are connected between the bases of the NPN transistors 81 and 82 via the capacitors 88 and 89 for blocking the flow of direct current, respectively.

In this embodiment also, the capacitances of the capacitors 88 and 89 are equal to each other, and the capacitances of the capacitors 83 and 84 are equal to each other ($C_{88} = C_{89}$, and $C_{83} = C_{84}$), and if the parameters of the constant-current sources 85 and 86, and the NPN transistors 81 and 82 are made to be the same, a completely balanced state is reached, and oscillation amplitude does not occur in the collectors of the NPN transistors 81 and 82. Therefore, in this case, a capacitor 90 (functions in the same way as the capacitor 8 in Fig. 3) for grounding a power terminal 91, such as that shown in Fig. 2, is not required.

In this embodiment also, by using a differential amplifier and a one-port-type SAW resonator and by using elements having the same parameters as those of the first embodiment, a completely balanced condition is set. Thus, it becomes possible to generate a high-frequency signal without adjustments and with a high degree of accuracy.

These oscillation circuits are suitable for a case in which they are contained in a high-frequency IC. When, in particular, the impedance to the power source and the grounding conductor cannot be sufficiently lowered, the oscillation circuits may be used in a case in which a high-frequency signal is generated with a high degree of accuracy and without adjustments.

Although in the above-described embodiment an NPN transistor is used as an active element which constitutes a differential amplifier, it is also possible to use a PNP transistor or an FET

As has been described up to this point, according

to the oscillation circuit described in claim 1 and the oscillation method described in claim 13, since the output of the differential amplifier is positively fed back to its input, and a one-port-type SAW resonator connected between a pair of active elements is caused to perform an oscillation operation, it becomes possible to generate a high-frequency signal without adjustments and with a high degree of accuracy without being affected by temperature change and ageing. Therefore, the present invention may be applied to, for example, a case in which a second intermediate frequency signal of a digital broadcast satellite is generated.

Many different embodiments of the present invention may be constructed without departing from the spirit and scope of the present invention. It should be understood that the present invention is not limited to the specific embodiments described in this specification. To the contrary, the present invention is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the invention as hereafter claimed. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications, equivalent structures and functions.

Claims

1. An oscillation circuit for generating a high-frequency signal, said oscillation circuit comprising:

   a differential amplifier having at least a pair of active elements which are differentially connected;
   a positive feedback circuit for positively feeding back the output of said said differential amplifier to the input thereof; and
   a one-port-type SAW resonator connected between said pair of active elements.

2. An oscillation circuit according to claim 1, wherein said active elements are bipolar transistors.

3. An oscillation circuit according to claim 2, wherein said one-port-type SAW resonator is connected between the collectors of a pair of said bipolar transistors.

4. An oscillation circuit according to claim 3, wherein said one-port-type SAW resonator is connected between the collectors of a pair of said bipolar transistors each via a pair of capacitors for blocking the flow of direct current.

5. An oscillation circuit according to claim 3, wherein said positive feedback circuit comprises a first capacitor which connects the collector of a first bipolar transistor which forms said differential amplifier to
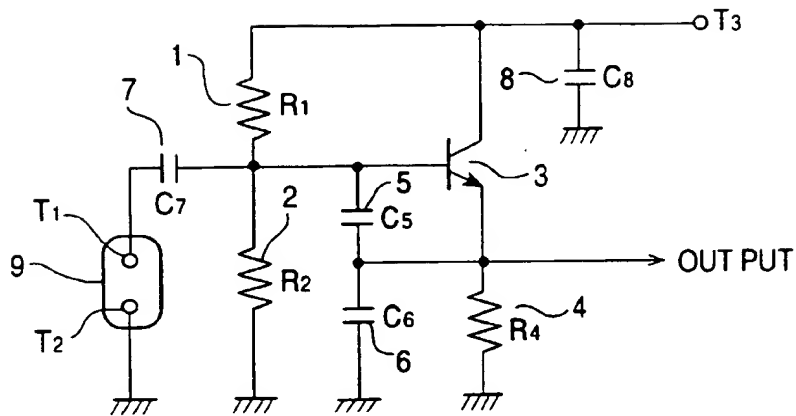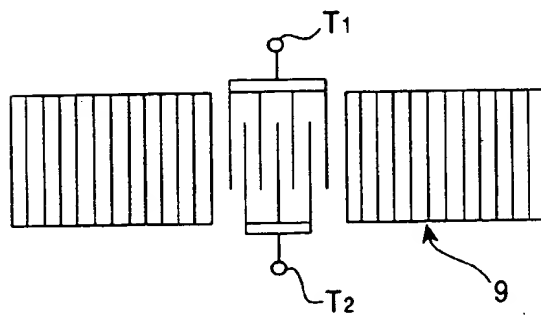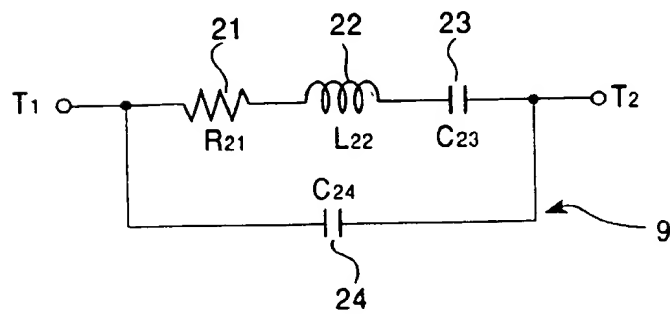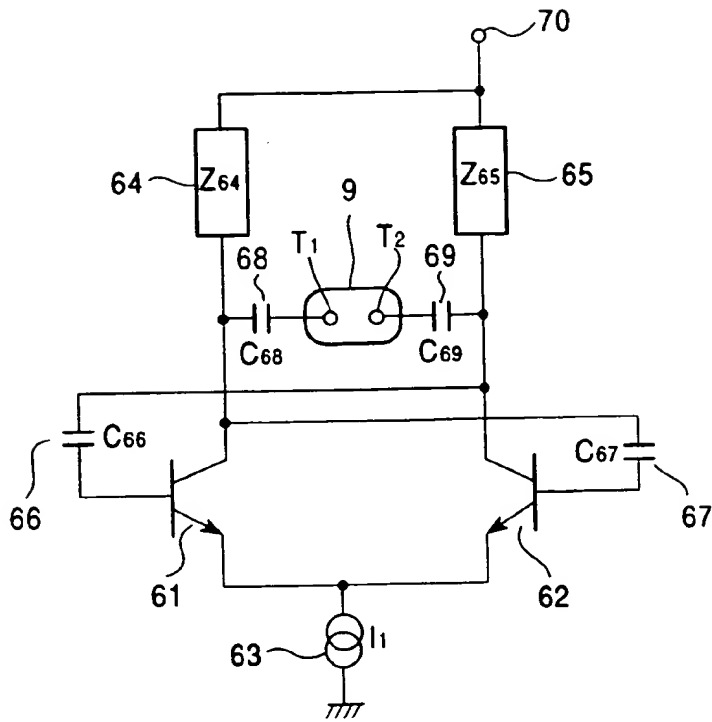
FIG. 3

FIG. 4

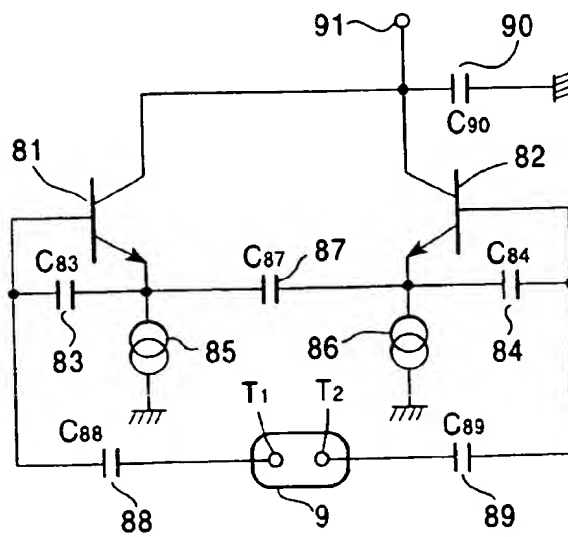

FIG. 5

FIG. 1

FIG. 2

EP 0 767 532 A1

EUROPEAN SEARCH REPORT

European Patent Office

Application Number

EP 96 30 7269

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 3 787 612 A (DE VRIES A ET AL) 22 January 1974	1,2,13, 14	H03B5/32
Y	* column 8, line 20 - column 9, line 33; figure 1 *	3-12,15, 16	
Y	EP 0 351 153 A (MATSUSHITA ELECTRIC IND CO LTD) 17 January 1990 * page 1, line 48 - page 4, line 33; figure 2 *	3-9,15	
Y	EP 0 335 493 A (TOKYO SHIBAURA ELECTRIC CO) 4 October 1989 * column 9, line 57 - column 10, line 33; figure 7 *	10-12,16	
A	EP 0 220 914 A (PLESSEY OVERSEAS) 6 May 1987 * abstract; figure 2 *	3-9,15	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H03B
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 December 1996	Dhondt, I

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